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The Lessons of Japan and Radiation: Recognizing the Good and Ill of a Powerful Tool

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The massive devastation of Japan by an earthquake and tsunami is an overwhelming tragedy, and the world mourns for its victims. The brute destruction of the sophisticated infrastructure by natural forces and subsequent inclement weather continue to impede rescue efforts. But while the destruction is viewed worldwide, it is what we cannot see—the risks associated with the release of radiation from a damaged nuclear power plant—that has diverted and slowed rescue efforts, and worried the world.

The potential of a disaster occurring from the peaceful use of radiation in Japan more than 65 years after the wartime devastation wrought by nuclear weapons is fateful. While the radiation that caused the wartime devastation could not be seen, the aftermath was viewed worldwide. Seeing the consequences of nuclear war struck fear into every world leader. This fear helped foster a mutual détente during the Cold War, and a line for humanity that could not be crossed. Over the past decade, the world has worried about rogue nations with nuclear weapons, and whether this line protecting humanity will be breached.

Power Plant Incidents

Even when nuclear energy is applied for good in power plants, questions arise about whether the risks of radiation outweigh its potential benefits to satisfy progress powered by energy. Although there were no deaths and no long-term effects to health or the environment associated with the Three Mile Island incident in 1979,[1] the event had a profound impact on public opinion, and the United States turned away from nuclear energy.

In contrast, just 7 years later in 1986, the Chernobyl incident in the former Union of Soviet Socialist Republics released massive amounts of radioactive material into the environment.[2] Boron and sand, poured from the air, was not effective in containing the radiation. Later, a temporary concrete sarcophagus entombed the damaged unit. Access to a 30-km area was closed, and nearly half a million people were evacuated. Among the 600 workers on-site at the time of the accident, 2 died within hours and 134 received high radiation doses and developed acute radiation sickness. More than 600,000 workers were involved in the Chernobyl cleanup, and 200,000 recovery workers continue to be monitored for late radiation effects. About 4,000 cases of thyroid cancer were diagnosed among children who drank contaminated milk; 99% of these children have been successfully treated. The U.S. Nuclear Regulatory Agency emphasizes that U.S. reactors have different plant designs, broader shutdown margins, and protective operational controls.

The *potential* for devastation caused by an unseen and insidious danger significantly stifled the development of nuclear power in the United States for more than 40 years; 12 proposed reactors were cancelled, and the construction of 8 that were already underway was suspended. Since 1990, only 5 new nuclear reactors have been built, and only 1 is under construction. Despite this, in 2009 the United States produced more than 30% of the worldwide nuclear generation of electricity, with 104 nuclear reactors in 31 states producing 799 billion kWh, representing over 20% of the country's total electrical output.[3] Approximately 5 new units are planned to come online by 2018, the first of 24 new nuclear reactors approved in mid-2007. It is now unclear whether the plans for construction of these reactors will also be suspended in reaction to the tragedy in Japan.

Advances in Radiation Oncology

In the context of these events, the use of nuclear power continues to be debated, but meanwhile, the diagnosis and treatment of cancer with radiation has made tremendous technologic progress. The radiographic early detection of cancer, particularly with mammography, has significantly improved cancer survival rates. Technologic improvements in computed tomography (CT) and the development of magnetic resonance imaging (MRI) and positron-emission tomography (PET) have transformed oncologic practice.

For radiation oncology, there have been three major advances. First, the use of radiation therapy has expanded, in conjunction with more conservative surgical approaches to accomplish organ preservation. Second, multidisciplinary care has expanded to include multimodality cancer therapy, particularly the administration of chemotherapy during the course of radiation. Third, radiation to the tumor has become more precisely targeted, allowing the safe administration of higher total doses of radiation. All of these advances depended on the development of more sophisticated linear accelerators, radiation treatment planning, and verification of the delivered radiation dose, which ushered in intensity-modulated radiation therapy (IMRT) and proton therapy.

Debates and Recommendations

Despite these advances in oncologic care, disagreements about the risks of radiation used in medicine are ongoing. In particular, the risks of radiation administered during mammography continue to be debated, although mammography has been routinely and safely used to detect breast cancer for more than 30 years. This debate, however, transformed into a recommendation from a recently convened government task force to restrict mammography for women under the age of 50 years. In February 2010, the FDA published a policy paper entitled, "Initiative to

Reduce Unnecessary Radiation Exposure from Medical Imaging," which included three recommendations.[4] In order to promote safe use of medical imaging devices, the FDA will:

1. Establish requirements for manufacturers of CT and fluoroscopic devices to incorporate additional safeguards into equipment design, labeling, and user training.

2. Partner with the Centers for Medicare and Medicaid Services (CMS) to incorporate key quality assurance practices into accreditation and participation criteria for imaging facilities and hospitals.

3. Recommend that the health-care professional community, in collaboration with FDA, continue efforts to develop diagnostic reference levels for CT, fluoroscopy, and nuclear medicine procedures locally and also through a national radiation dose registry.

The FDA emphasized the "appropriate justification for ordering and performing each procedure" and the "careful optimization of the radiation dose during each procedure" in December 2010. The aim is to record the radiation dose from each CT, fluoroscopy, and nuclear medicine procedure (including PET). These records of radiation dose will then be sent to a radiation dose registry for the collection, initially, of de-identified patient radiation dose data. Pooling dose data across imaging facilities nationwide, a national radiation dose registry will initially be used "to support the development of diagnostic reference levels where they do not yet exist," and "allow for broad validation of those levels that have been developed to date."

Included in the December 2010 document is an initiative to increase patient awareness regarding the risks of radiation with the development of a "patient medical imaging record card," which will compile the patient's total radiation exposure from every radiologic procedure performed. This radiation exposure summary document ultimately will be incorporated into the patient's medical record. Significant potential drawbacks of the card include questions about how the patient and non-radiologist physicians will interpret the data (particularly in differentiating localized vs whole-body radiation exposure) and whether the data will be used to limit future radiation procedures (which could be especially problematic for cancer diagnosis, treatment, and follow-up).

Conclusions

The good or ill of radiation, in providing power or in medical care, must be grounded in data, and not based on emotion and fear. Risks associated with nuclear energy, like those with radiology in medicine, are well controlled, and these applications of radiation improve and save lives. Nevertheless, policymaking must always consider unintended consequences. With potential significant restrictions looming in nuclear energy and the medical application of radiation, we hope that we will not also see risks resulting from significant energy shortages, like frail individuals dying in their homes from excessive heat without air conditioning, and a reversal of the improvements achieved in cancer survival.

References

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